

INCREASED OIL PRODUCTION AND RESERVES UTILIZING  
SECONDARY/TERTIARY RECOVERY TECHNIQUES ON SMALL  
RESERVOIRS IN THE PARADOX BASIN, UTAH

Annual Report  
February 9, 1999-February 8, 2000

By  
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Date Published: July 2000

Work Performed Under Contract No. DE-FC22-95BC14988

Utah Geological Survey  
Salt Lake City, Utah



National Petroleum Technology Office  
U.S. DEPARTMENT OF ENERGY  
Tulsa, Oklahoma

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Increased Oil Production and Reserves Utilizing Secondary/Tertiary Recovery Techniques on  
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## CONTENTS

ABSTRACT.....	iii
EXECUTIVE SUMMARY .....	iv
ACKNOWLEDGEMENTS.....	vi
1. INTRODUCTION.....	1-1
2. IMPLEMENTATION OF PILOT CARBON DIOXIDE FLOOD DEMONSTRATION.....	2-1
2.1 Current Status .....	2-1
2.2 References .....	2-1
3. TECHNOLOGY TRANSFER .....	2-1
3.1 Utah Geological Survey <i>Petroleum News, Survey Notes,</i> and Internet Web Site .....	3-1
3.2 Presentations.....	3-3
3.3 Project Presentations .....	3-3

## FIGURES

Figure 1.1. Location of project fields.....	1-1
Figure 3.1. The Paradox basin project page from the UGS Internet web site .....	3-2

## ABSTRACT

The Paradox basin of Utah, Colorado, and Arizona contains nearly 100 small oil fields producing from carbonate buildups or mounds within the Pennsylvanian (Desmoinesian) Paradox Formation. These fields typically have one to four wells with primary production ranging from 700,000 to 2,000,000 barrels (111,300-318,000 m<sup>3</sup>) of oil per field at a 15 to 20 percent recovery rate. At least 200 million barrels (31,800,000 m<sup>3</sup>) of oil is at risk of being unrecovered in these small fields because of inefficient recovery practices and undrained heterogeneous reservoirs. Five fields (Anasazi, Mule, Blue Hogan, Heron North, and Runway) within the Navajo Nation of southeastern Utah were evaluated for waterflood or carbon-dioxide (CO<sub>2</sub>)-miscible flood projects based upon geological characterization and reservoir modeling. Geological characterization on a local scale focused on reservoir heterogeneity, quality, and lateral continuity as well as possible compartmentalization within each of the five project fields. The results can be applied to other fields in the Paradox basin and the Rocky Mountain region, the Michigan and Illinois basins, and the Midcontinent region.

Simulation of Anasazi field has shown that a CO<sub>2</sub> flood is technically superior to a waterflood and economically feasible. The key to increasing ultimate recovery from the field (and similar fields in the basin) is to design a CO<sub>2</sub>-miscible flood project capable of forcing oil from high-storage-capacity but low-recovery supra-mound units into the high-recovery mound-core units. For Anasazi field, an optimized CO<sub>2</sub> flood is predicted to recover a total 4.21 million stock tank barrels (0.67 million m<sup>3</sup>) of oil representing in excess of 89 percent of the original oil in place.

Based on the simulation results, Anasazi field was chosen as the best candidate for a pilot CO<sub>2</sub>-flood pilot demonstration project. The field demonstration includes: obtaining a CO<sub>2</sub> source and fuel gas (for the compressor), conducting a CO<sub>2</sub> injection test(s), rerunning project economics, drilling a development well(s) (vertically or horizontally), purchasing and installing injection facilities, monitoring field performance, and validating and evaluating the techniques.

The only CO<sub>2</sub> line in the area, which is owned and operated by Mobil (now Exxon/Mobil), is currently operating at full capacity supplying CO<sub>2</sub> to wells on the north side of the San Juan River as part of a large CO<sub>2</sub> flood of the giant Greater Aneth field. Plans to expand the pipeline capacity and extend it to Greater Aneth wells south across the river, and thus closer to Anasazi field, were delayed about a year and a half due to low oil prices in 1998 and early 1999, and a backlog of higher priority projects of the Greater Aneth field operators. These factors, combined with uncertainty related to the merger of Mobil and Exxon, have delayed the availability of CO<sub>2</sub> for the Anasazi field demonstration for at least two years. Ultimately when completed, the demonstration will prove (or disprove) CO<sub>2</sub>-flood viability, and thus help determine whether the technique can be applied to the other small carbonate buildup reservoirs in the Paradox basin.

Technology transfer during the fifth project year consisted of booth displays for various national and regional professional conventions, technical presentations, publications, newsletters, and a project home page on the Internet.

## EXECUTIVE SUMMARY

The primary objective of this project is to enhance domestic petroleum production by field demonstration and technology transfer of an advanced-oil-recovery technology in the Paradox basin, southeastern Utah. If this project can demonstrate technical and economic feasibility, the technique can be applied to approximately 100 additional small fields in the Paradox basin alone, and result in increased recovery of 150 to 200 million barrels (23,850,000-31,800,000 m<sup>3</sup>) of oil. This project is designed to characterize five shallow-shelf carbonate reservoirs in the Pennsylvanian (Desmoinesian) Paradox Formation and choose the best candidate for a pilot demonstration project for either a waterflood or carbon-dioxide-(CO<sub>2</sub>-) miscible flood project. The field demonstration, monitoring of field performance, and associated validation activities will take place within the Navajo Nation, San Juan County, Utah.

The Utah Geological Survey (UGS) leads a multidisciplinary team to determine the geological and reservoir characteristics of typical, small, shallow-shelf carbonate reservoirs in the Paradox basin. The Paradox basin project team consists of the UGS (prime contractor), Harken Southwest Corporation, and several subcontractors. This research is performed under the Class II Oil Program of the U.S. Department of Energy, National Petroleum Technology Office (NPTO) in Tulsa, Oklahoma. This report covers research and technology transfer activities for the fourth project year (February 9, 1999 through February 8, 2000).

Reservoir simulations were completed on both the Anasazi and Runway project fields during Phase I. The key to increasing ultimate recovery from these fields (and similar fields in the basin) is to design a CO<sub>2</sub>-miscible flood project capable of forcing oil from high-storage-capacity but low-recovery supra-mound units into the high-recovery mound-core units. Simulation of Anasazi field showed that a CO<sub>2</sub> flood is technically superior to a waterflood, and economically feasible. For Anasazi field, an optimized CO<sub>2</sub> flood is predicted to recover a total 4.21 million stock tank barrels (0.67 million m<sup>3</sup>) of oil. This represents an increase of 1.65 million stock tank barrels (0.26 million m<sup>3</sup>) of oil over predicted primary depletion recovery as of January 1, 2012. The projected 4.21 million stock tank barrels of oil production represents in excess of 89 percent of the original oil in place.

Based on the simulation results, Anasazi field was chosen as the best candidate for a pilot CO<sub>2</sub>-flood pilot demonstration project. The field demonstration includes: obtaining a CO<sub>2</sub> source and fuel gas (for the compressor), conducting a CO<sub>2</sub> injection test(s), rerunning project economics, drilling a development well(s) (vertically or horizontally), purchasing and installing injection facilities, monitoring field performance, and validating and evaluating the techniques.

At this time, there is only one CO<sub>2</sub> source in the area, a pipeline which is owned and operated by Mobil (now Exxon/Mobil). The CO<sub>2</sub> line is currently operating at full capacity supplying CO<sub>2</sub> to wells on the north side of the San Juan River as part of a large CO<sub>2</sub> flood of the giant Greater Aneth field. Plans to expand the pipeline capacity and extend it to Greater Aneth wells south across the river, and thus closer to Anasazi field, were delayed about a year and a half due to low oil prices in 1998 and early 1999, and a backlog of higher priority projects of the Greater Aneth field operators.

These factors, combined with uncertainty related to the merger of Mobil and Exxon, have delayed the availability of CO<sub>2</sub> for the Anasazi field demonstration for at least two years. However, the Utah Geological Survey and our industry partner Harken Energy Corporation still desire to see the project completed through the demonstration phase, and will continue to carefully monitor the

CO<sub>2</sub> availability situation. Ultimately when completed, the demonstration will prove (or disprove) CO<sub>2</sub>-flood viability, and thus help determine whether the technique can be applied to the other small carbonate buildup reservoirs in the Paradox basin.

Technology transfer during the fifth project year consisted of displaying project materials at: the UGS booth during the national and regional conventions of the American Association of Petroleum Geologists. In addition, five technical presentations were made to geological associations. Project team members published abstracts, quarterly and annual reports, newsletters, and technical journal papers detailing project progress and results. The UGS maintains a home page for the Paradox basin project on the Internet.

## ACKNOWLEDGMENTS

This research is performed under the Class II Oil Program of the U.S. Department of Energy (DOE), National Petroleum Technology Office, Tulsa, Oklahoma, contract number DE-FC22-95BC14988. The Contracting Officer's Representative/Project Manager is Gary D. Walker. Additional funding is being provided by Harken Southwest Corporation, Houston, Texas, David Gibbs, Vice President, Engineering and Development, and Richard O. Cottle, Vice President, Engineering; and the Utah Office of Energy and Resource Planning, Jeff Burks, Director.

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Utah Geological Survey *Petroleum News* was edited by Tim Madden. Jim Parker, Vicky Clarke, Cheryl Wakefield, Michele Hoskins, Kevin McClure, Carolyn Olsen, and Dan Aubrey (Utah Geological Survey) drafted figures, designed displays, photographed core, and assembled reports.

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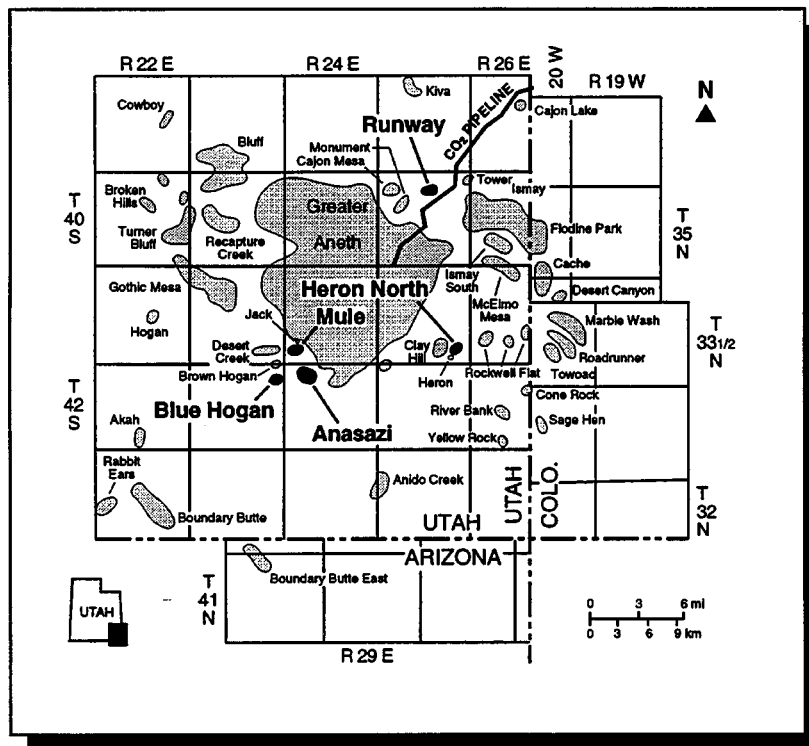
# 1. INTRODUCTION

Over 400 million barrels (63,600,000 m<sup>3</sup>) of oil have been produced from shallow-shelf carbonate reservoirs in the Pennsylvanian (Desmoinesian) Paradox Formation in the Paradox basin of Utah, Colorado, and Arizona. With the exception of the giant Greater Aneth field, 100-plus oil fields in the basin typically contain 2 to 10 million barrels (318,000-1,590,000 m<sup>3</sup>) of original oil in place per field. To date, none of these small fields have been the site of secondary/tertiary recovery techniques used in large carbonate reservoirs. Most of these fields are characterized by extremely high initial production rates followed by a very short production life (primary), and hence early abandonment. At least 200 million barrels (31,800,000 m<sup>3</sup>) of oil is at risk of being left behind in these small fields because of inefficient recovery practices and undrained heterogeneous reservoirs. The purpose of this multi-year project is to enhance domestic petroleum production by field demonstration and technology transfer of an advanced-oil-recovery technology in the Paradox basin.

The benefits expected from the project are: (1) increasing recoverable reserves by identifying untapped compartments created by reservoir heterogeneity, (2) increasing deliverability through a carbon-dioxide- (CO<sub>2</sub>-) miscible flood which exploits the reservoir along optimal fluid-flow paths, (3) identifying reservoir trends for field extension drilling and stimulating exploration in Paradox basin fairways, (4) preventing premature abandonment of numerous small fields, (5) reducing development costs by more closely delineating minimum field size and other parameters necessary to a successful flood, (6) allowing limited energy investment dollars to be used more productively, and (7) increasing royalty income to the Navajo Nation; Federal, State, and local governments; and

fee owners. These benefits also apply to other areas in the Rocky Mountain region, the Michigan and Illinois basins, and the Midcontinent.

The geological and reservoir characteristics of five fields (figure 1.1) that produce oil and gas from the Desert Creek zone of the Paradox Formation were quantitatively determined by a multidisciplinary team. Anasazi field was chosen as the best candidate for a pilot CO<sub>2</sub>-flood demonstration project after reservoir simulations were completed on both the Anasazi and Runway fields. To evaluate these fields as models for other shallow-shelf carbonate reservoirs, the Utah Geological Survey (UGS),



**Figure 1.1. Location of project fields (dark shaded areas with names in bold type) in the southwestern Paradox basin on the Navajo Nation, San Juan County, Utah.**

Harken Southwest Corporation, Eby Petrography & Consulting Inc., and REGA Inc. entered into a cooperative agreement with the U.S. Department of Energy (DOE) as part of its Class II Oil program.

A two-phase approach is being used to increase production and reserves from the shallow-shelf carbonate reservoirs in the Paradox basin. Phase I was the geological and reservoir characterization of the five small fields. Work completed during this phase of the project included:

- (a) field data collection and compilation,
- (b) determination of diagenetic fabrics and porosity types found in the various hydrocarbon-bearing rocks of each field,
- (c) field-scale geologic analysis to focus on the reservoir heterogeneity, quality, and lateral continuity versus compartmentalization,
- (d) reservoir geostatistical modeling,
- (e) history matching and reservoir CO<sub>2</sub>-flood and waterflood simulations,
- (f) field reserves and secondary/tertiary recovery determination,
- (g) economic assessments of CO<sub>2</sub> floods for Anasazi and Runway fields, and
- (h) recommendation of plans for pilot flood implementation and production scenarios for Phase II, the field demonstration project.

Phase II is a demonstration project on Anasazi field, which was selected from the characterization study, using a CO<sub>2</sub>-miscible flood. This technique was identified as having the greatest potential for increased well productivity and ultimate recovery. The demonstration project will include:

- (a) acquiring a CO<sub>2</sub> source for the flood project,
- (b) acquiring a fuel gas source for the compressor,
- (c) conducting a CO<sub>2</sub> injection test(s),
- (d) rerunning project economics,
- (e) drilling a development well(s), vertically or horizontally, to facilitate sweep during the pilot flood,
- (f) purchasing and installing injection facilities,
- (g) flood management, monitoring field performance, and evaluation of results, and

- (h) determining the application of the project to similar fields in the Paradox basin and throughout the U.S.

The results of this project are being transferred to industry and other researchers through a petroleum extension service, creation of digital databases for distribution, technical workshops and seminars, field trips, technical presentations at national and regional professional meetings, maintaining a project home page on the Internet, and publication in newsletters and various technical or trade journals.

This report is organized into three sections: (1) Introduction, (2) Implementation of Pilot Carbon Dioxide Flood Demonstration, and (3) Technology Transfer. This report presents the progress of ongoing research and is not intended as a final report. Whenever possible, preliminary conclusions have been drawn based on available data.

## **2. IMPLEMENTATION OF PILOT CARBON DIOXIDE FLOOD DEMONSTRATION**

### **2.1 Current Status**

Results from Budget Period I of this project showed that a carbon dioxide (CO<sub>2</sub>) flood was technically superior to a waterflood and was economically feasible on typical small, shallow-shelf carbonate buildup reservoirs in the Paradox basin (Chidsey and Allison, 1998; Chidsey and others, 1999). Based on the geologic characterization study, reservoir performance predictions, and the associated economic assessment of implementing a CO<sub>2</sub> flood in the Anasazi field, San Juan County, Utah (figure 1.1), an optimized CO<sub>2</sub> flood is predicted to recover 4.21 million stock tank barrels (STB) (0.67 million m<sup>3</sup>) of oil. This represents an increase of 1.65 million STB (0.26 million m<sup>3</sup>) of oil over predicted primary depletion recovery at January 1, 2012. If the CO<sub>2</sub> flood performs as predicted, it is a financially robust process for increasing the reserves of the Anasazi field and similar small fields in the basin.

Budget Period II of the project involves the implementation of a pilot CO<sub>2</sub>-flood demonstration on Anasazi field. The field demonstration includes: obtaining a CO<sub>2</sub> source and fuel gas for the compressor, conducting a CO<sub>2</sub> injection test(s), rerunning project economics, drilling a development well(s) (vertically or horizontally), purchasing and installing injection facilities, monitoring field performance, and validation and evaluation of the techniques. The demonstration will prove (or disprove) CO<sub>2</sub>-flood viability and thus help determine whether the technique can be applied to the other small carbonate buildup reservoirs in the Paradox Basin. Obtaining a CO<sub>2</sub> source is the key to beginning this demonstration.

At this time, there is only one CO<sub>2</sub> source in the area, a pipeline (figure 1.1) which is owned and operated by Mobil (now Exxon/Mobil). The CO<sub>2</sub> line is currently operating at full capacity supplying CO<sub>2</sub> to wells on the north side of the San Juan River as part of a large CO<sub>2</sub> flood of the giant Greater Aneth field. In 1998, 15.2 billion cubic feet (BCF) of CO<sub>2</sub> was injected into the Desert Creek reservoir (Paradox Formation) in the field (Cordova, 1999). Plans to expand the pipeline capacity and extend it to Greater Aneth wells south across the river, and thus closer to Anasazi field, were delayed about a year and a half due to low oil prices in 1998 and early 1999, and a backlog of higher priority projects of the Greater Aneth field operators.

These factors, combined with uncertainty related to the merger of Mobil and Exxon, have delayed the availability of CO<sub>2</sub> for the Anasazi field demonstration for at least two years. However, the Utah Geological Survey and our industry partner Harken Energy Corporation still desire to see the project completed through the demonstration phase, and will continue to carefully monitor the CO<sub>2</sub> availability situation. Most operators in the basin are small independent companies that need to see a successful and economically viable CO<sub>2</sub>-flood demonstrated on a small field similar to theirs before they will invest in CO<sub>2</sub> acquisition, new pipelines, injection wells, and additional field facilities.

### **2.2 References**

Chidsey, T.C., Jr., and Allison, M.L., 1998, Increased oil production and reserves utilizing secondary/tertiary recovery techniques on small reservoirs in the Paradox basin, Utah - annual report

for the period February 9, 1998 to February 8, 1999: U.S. Department of Energy, DOE/BC/14988-10, 66 p.

Chidsey, T.C., Jr., Eby, D.E., Lorenz, D.M., and Culham, W.E., 1999, Increased oil production and reserves utilizing secondary/tertiary recovery techniques on small reservoirs in the Paradox basin, Utah - annual report for the period February 9, 1998 to February 8, 1999: U.S. Department of Energy, DOE/BC/14988-12, 47 p.

Cordova, Lisha, 1999, Utah annual injection report 1998: Utah Division of Oil, Gas and Mining, non-pagenated.

### 3. TECHNOLOGY TRANSFER

The UGS is the Principal Investigator and prime contractor for five government-industry cooperative petroleum-research projects, including two in the Paradox basin. These projects are designed to improve recovery, development, and exploration of the nation's oil and gas resources through use of better, more efficient technologies. The projects involve detailed geologic and engineering characterization of several complex heterogeneous reservoirs. The Class II Paradox basin (the project for this report and a recently awarded Class Revisit project) and the Class I Bluebell field (Uinta Basin) projects include practical oil-field demonstrations of selected technologies. The fourth project involves geological characterization and reservoir simulation of the Ferron Sandstone on the west flank of the San Rafael uplift as a surface analogue of a fluvial-dominated, deltaic reservoir. The fifth project involves establishing a log-based correlation scheme for the Tertiary Green River Formation in the southwestern Uinta Basin to help identify new plays and improve the understanding of producing intervals. The DOE and multidisciplinary teams from petroleum companies, petroleum service companies, universities, private consultants, and state agencies are co-funding the five projects.

The UGS will release all products of the Paradox basin project in a series of formal publications. These will include all the data as well as the results and interpretations. Syntheses and highlights will be submitted to refereed journals as appropriate, such as the *American Association of Petroleum Geologists (AAPG) Bulletin* and *Journal of Petroleum Technology*, and to trade publications such as the *Oil and Gas Journal*. A summary article was published in the *Oil & Gas Journal* describing the facies and reservoir characteristics of the project fields, and the Anasazi field and Runway field modeling and simulation results. This information will also be released through the UGS periodicals *Petroleum News* and *Survey Notes*, and on the project Internet home page.

Project publications, materials, plans, and objectives were displayed at the UGS booth during the AAPG Annual Convention, April 11-14, 1999, in San Antonio, Texas, and the Rocky Mountain Section, August 8-11, 1999, in Bozeman, Montana. Three to four UGS scientists staffed the display booth at these events. Project displays will be included as part of the UGS booth at meetings throughout the duration of the project.

An abstract was submitted, and accepted, comparing Desert Creek regional facies characteristics of carbonate buildups/reservoirs in the Paradox Formation of southeastern Utah to modern analogs for technical presentations at the 2000 AAPG Annual Convention.

#### 3.1 Utah Geological Survey *Petroleum News*, *Survey Notes*, and Internet Web Site

The purpose of the UGS *Petroleum News* newsletter is to keep petroleum companies, researchers, and other parties involved in exploring and developing Utah energy resources, informed of the progress on various energy-related UGS projects. *Petroleum News* contains articles on: (1) DOE-funded and other UGS petroleum project activities, progress, and results, (2) current drilling activity in Utah including coalbed methane development, (3) new acquisitions of well cuttings, core, and crude oil at the UGS Geological Sample Library, and (4) new UGS petroleum publications. The purpose of *Survey Notes* is to provide nontechnical information on contemporary geologic topics, issues, events, and ongoing UGS projects to Utah's geologic community, educators, state and local officials and other decision makers, and the public. *Survey Notes* is published three times yearly and

*Petroleum News* is published semi-annually. Single copies are distributed free of charge and reproduction (with recognition of source) is encouraged. The UGS maintains a database that includes those companies or individuals specifically interested in the Paradox basin project (more than 300 as of February 2000) or other DOE-sponsored projects.

The UGS maintains a web site on the Internet, <http://www.ugs.state.ut.us/>. This site includes a page under the heading *Economic Geology Program*, that describes the UGS/DOE cooperative studies (Paradox basin, Ferron Sandstone, Bluebell field, Green River Formation), contains the latest issue of *Petroleum News*, and has a link to the U.S. Department of Energy web site. Each UGS/DOE cooperative study also has its own separate page on the UGS web site. The Paradox basin project page (<http://www.ugs.state.ut.us/paradox.htm>) contains: (1) a project location map, (2) a description of the project, (3) a list of project participants and their postal addresses and phone numbers, (4) executive summaries from the Annual Reports, (5) each of the project Quarterly Technical Progress reports, and (6) a reference list of all publications that are a direct result of the project (figure 3.1).

**Utah Geological Survey**

## Paradox Basin - DOE Class II Study

**Reports**

- ☐ [Project description](#)
- ☐ [Project participants](#)
- ☐ [First Annual Technical Report](#)
- ☐ [Second Annual Technical Report](#)
- ☐ [Quarterly Technical Progress Reports:](#)
  - ☐ [1995 1st Quarterly Report](#)
  - ☐ [1995 2nd Quarterly Report](#)
  - ☐ [1995 3rd Quarterly Report](#)
  - ☐ [1995 4th Quarterly Report](#)
  - ☐ [1996 1st Quarterly Report](#)
  - ☐ [1996 2nd Quarterly Report](#)
  - ☐ [1996 3rd Quarterly Report](#)
  - ☐ [1996 4th Quarterly Report](#)
  - ☐ [1997 1st Quarterly Report](#)
  - ☐ [1997 2nd Quarterly Report](#)
  - ☐ [1997 3rd Quarterly Report](#)

**References**

- ☐ [Publications resulting from the study](#)

**i** For more information on the Paradox Basin Project, contact Tom Chidsey, (801) 537-3364, email: [trugs.tchidsev@state.ut.us](mailto:trugs.tchidsev@state.ut.us). For copies of reports with tables and figures, contact Roger L. Bon, (801) 537-3363, email: [trugs.rbon@state.ut.us](mailto:trugs.rbon@state.ut.us).

[Bluebell Field Project / Ferron Sandstone Project](#)  
[Petroleum News / Economic Geology Program](#)

[UGS Home](#)

**Figure 3.1.** The Paradox basin project page, <http://www.ugs.state.ut.us/paradox.htm>, from the UGS Internet web site.

### 3.2 Presentations

The following technical and nontechnical presentations were made during the year as part of the Paradox basin project technology transfer activities. These presentations described the project in general and gave detailed information on the reservoir characterization, facies, exploration trends, recovery techniques, and reservoir models.

“Diagenetic Characterization of Shallow-Shelf Carbonate Reservoirs, Pennsylvanian Paradox Formation, Southern Paradox Basin, Utah,” by T.C. Chidsey, Jr., and D.E. Eby, American Association of Petroleum Geologists Annual Convention, San Antonio, Texas, April 1999. The presentation focused on reservoir pore types and diagenesis in the Desert Creek zone of the Paradox Formation in the five project fields, and how these factors were used in the modeling and flow simulations.

“Upper Devonian Carbonate Buildups Impersonating Paradox Basin Phylloid Algal Mounds” by D.E. Eby, Rocky Mountain Section of the SEPM (Society for Sedimentary Geology), April 1999, Denver, Colorado, and 11th Bathurst Conference, an international gathering of about 125 carbonate specialists at Cambridge University, United Kingdom, July 1999. The discussion compared the geologic characterization of carbonate mound buildups within the Paradox basin to potentially hydrocarbon-productive Devonian buildups in western Canada and eastern Europe.

“Increased Oil Production and Reserves Utilizing Secondary/Tertiary Recovery Techniques on Small Reservoirs in the Paradox Basin, Utah,” by T.C. Chidsey, Jr. and C.D. Morgan, DOE-sponsored 1999 Oil & Gas Conference - *Technology Options for Producer Survival*, June 1999, Dallas, Texas. The presentation summarized the project results to date and plans for the CO<sub>2</sub> pilot flood demonstration.

“Mule Field in the Paradox Basin of Southeastern Utah: A Case Study for Small Carbonate Buildups, Horizontal Drilling, and Carbon Dioxide Flooding,” by T.C. Chidsey, Jr., and D.E. Eby, American Association of Petroleum Geologists Rocky Mountain Section meeting, Bozeman, Montana, August 1999. The presentation described: (1) reservoir geometry, (2) facies, (3) lithology from core, (4) pore types and diagenesis, and (6) production and drilling history in the Desert Creek zone of the Paradox Formation, and how these factors can be used in modeling and flow simulations.

### 3.3 Project Publications

Chidsey, T.C., Jr., 1999, Increased Oil Production and Reserves Utilizing Secondary/Tertiary Recovery Techniques on Small Reservoirs in the Paradox Basin, Utah: 1999 Oil & Gas Conference - *Technology Options for Producer Survival*, Proceedings Volume, 24 p.

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Association of Petroleum Geologists Bulletin Annual Convention, Official Program with Abstracts, v. 8, p. A24.

—1999, Mule field in the Paradox basin of southeastern Utah - a case study for small carbonate buildups, horizontal drilling, and carbon dioxide flooding [abs.]: American Association of Petroleum Geologists Bulletin, v. 83, no. 7, p. 1180-1181.

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Eby, D.E., 1999, Upper Devonian carbonate buildups impersonating Paradox basin phylloid algal mounds: SEPM (Society for Sedimentary Geology) Newsletter v. 24, no. 4, p. 1 and 3.

—1999, Upper Devonian carbonate buildups impersonating Paradox basin phylloid algal mounds [abs.]: 11th Bathurst Meeting, Cambridge, UK, Journal of Conference Abstracts, v. 4, no. 2, p. 915.

Montgomery, S.L., Chidsey, T.C., Jr., Eby, D.E., Lorenz, D.M., and Culham, W.E., 1999, Pennsylvanian carbonate buildups, Paradox basin - increasing reserves in heterogeneous, shallow-shelf reservoirs: American Association of Petroleum Geologists Bulletin, v. 83, no. 2, p. 193-210.

—1999, Paradox study shows big oil potential with CO<sub>2</sub>: Oil & Gas Journal, v. 97, no. 18, p. 128-134.